MIM-104 Patriot

The Patriot is a fundamentally different SAM system comparing to any other previous types – US made and non US either – it is the first fully digital deployable land based SAM. The Patriot can be counted the first "network based" SAM system which was not static like the Nike and BOMARC SAMs were with the SAGE IADS (or Soviet SAMs with different IADS support). The Patriot battery and battalion themselves have the necessary deployable/mobile equipment to from a network fulfilling the requirements of IADS.

The Patriot has much more potential in many ways comparing to capabilities of the SAGE it could get target data and coordinates from many sources to create a real-time tactical map which made unnecessary to use the radar of the battery in some cases before missile guidance. The Patriot can operate as integrated part of an IADS in a much more dynamic environment than homeland defense of USA while the system at least was deployable and not totally static as were SAGE + Nike and BOMARC SAM systems.

The basic composition of a Patriot battery is fundamentally different to any previous SAM systems even comparing to the most similar S-300PT/PS which had very close IOC (1978/1983). The S-300 family is very often is compared with Patriot regardless their basic design conceptions are mostly different but they are similar in some technical aspects and solutions:

- Patriot was designed assuming USA/NATO quickly gains the air superiority, the goal is defending a specific object area defense above troops.

- 360 degree missile launch and target tracking capability is not possible concerning on a single Patriot SAM battery. For a single battery is a main threat direction to the opposite direction a single battery is defenseless is not able to operate. Patriot has only 270 degree missile launch capability.

- Regardless all of equipment installed on self-propelled or towed vehicles Patriot is not as mobile as S-300 or any other Soviet army air defense system the relocation time is in hour scale. (Mobility and quick relocation is not a disadvantage regardless USA/NATO intentions marching from West Germany to Moscow.)

- The Patriot has only single radar for target acquisition/search and for fire control (missile guidance) it was designed assuming many other sources (other Patriot batteries, E-3 AWACS, AEGIS system, other static EW radars, etc.) are available to have a picture about the tactical situation.

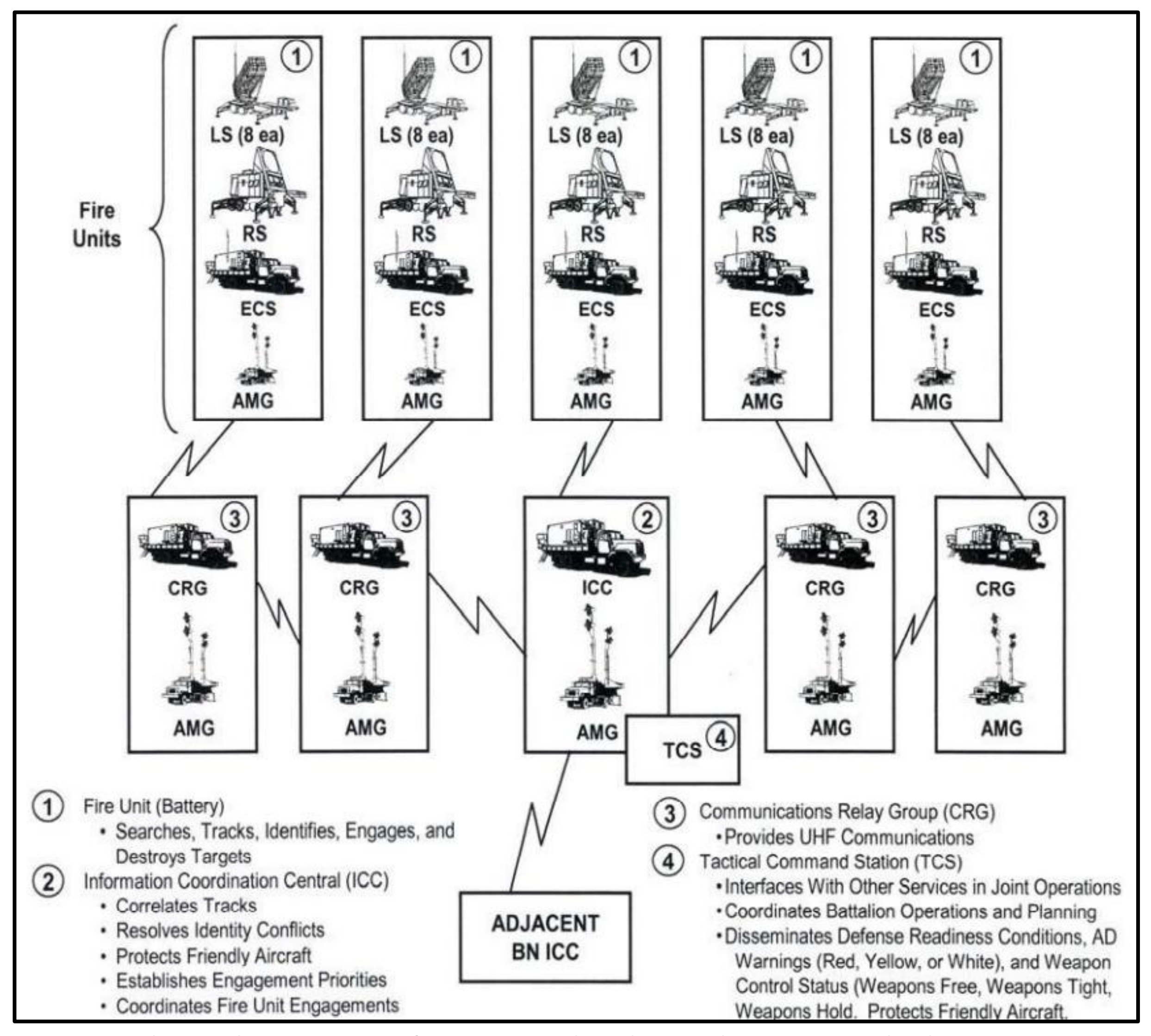
Comparing to the list above during the design of S-300 (SA-10) the conception was different which came from experiences from Vietnam conflict:

- The opponent has the air superiority the main priority is defending a small area or an object. Because of the air superiority the "hit and run" tactic is needed especially in a conflict between 3rd world Soviet friendly country and USA when USA very likely has air superiority from hour 0. In the Soviet Union and WPACT countries S-300 batteries were deployed on static sites.

- 360 degree missile launch and target search capability. Of course the fire arc of the fire control radar is restricted (90 or 105 degree) but in can be set the radar to any direction. The Patriot has restricted engagement zone comparing to S-300.

- Quick relocation, in some cases 5 minus readiness is possible with limited capability. (In case full low level capability has to be ensured the relocation time is in hour scale. See in more detailed in the chapter about S-300/400 SAM family.)

- S-300 still used many types of radar for target acquisition and fire control thanks to this aspect all batteries have very good low level search capability.

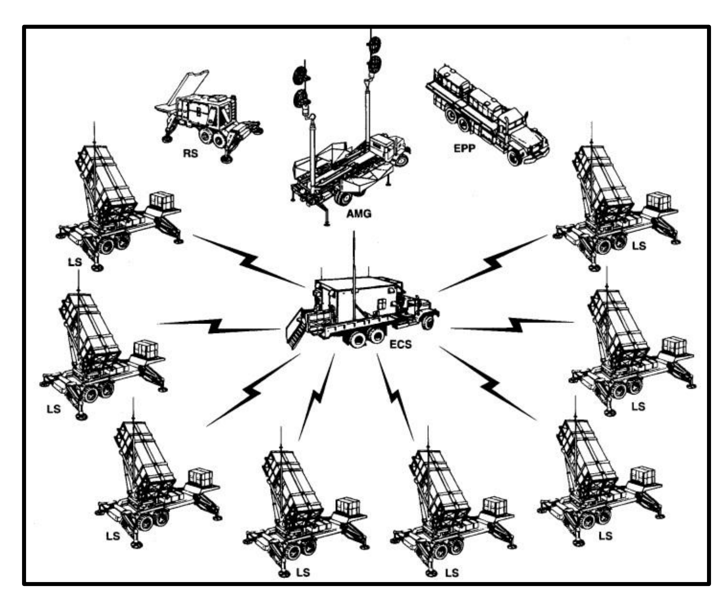


Above is the composition of a Patriot SAM battalion; on the image are only 5 batteries while a fully battery typically has 6 batteries.

A full Patriot battalion typically it built up from 6 fire unit (FU = battery) but when Patriot entered in service for a time before battalions could be fully equipped some battalions had only 3 FU and FUs did not have all the missile launchers (LS). The main equipment of Patriot battalion is the followings:

- ICC (information and coordination center), battalion level fire control center
- Main equipment of a FU (battery) is the followings:
  - engagement control station (ECS) serves as fire control/guidance and command center
  - radar station (RS) is the target acquisition and fire control radar
  - launching station (LS) are the missile launchers in two sections in total 8 pcs (2x4) vehicles
  - electric power plant (EPP) with 2x150 kW capacity

- Each FU has a communication group with the following main equipment:
    - antenna mast group (AMG);it provides UHF communication
    - communication relay group (CRG)
    - electric power unit (EPU) with 2x60 kW capacity



Main elements of a Patriot fire unit; the physical layout of the battery is very different from what the drawing suggests.

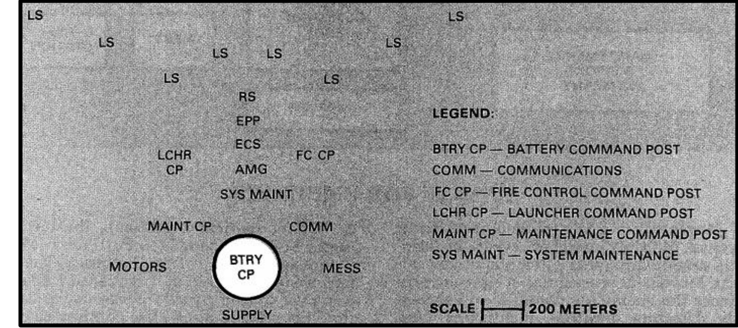
The ICC provides the link between the FU of the battalion and also with the ICC of adjacent Patriot battalions and the command center of the air defense brigade of the Army.

The CRG and AMG provide the link between the FUs and ICC of the battalion. Thanks to the network based structure Patriot had new features and capabilities concerning on anti-jam capabilities, IFF, target sorting and many other areas comparing to even the most advanced HAWK variant at the time.

Developer of the AGM-88 HARM anti-radiation missile (ARM) and the Patriot was the same (Raytheon) which left distinct mark on the basic structure of the Patriot. Very likely this is the reason why is not crew in RS. Thanks to this in case the radar is hit by ARM (or any weapon) the crew is not sentenced to death unlike the Soviet/Russian S-300/400 family where the crew is even today is sitting under the radar in a cabin. (Even the HAWK used the same conception regarding crew location long before appearing the first ARMs.) This conception had very strong impact on the layout of a FU according to followings:

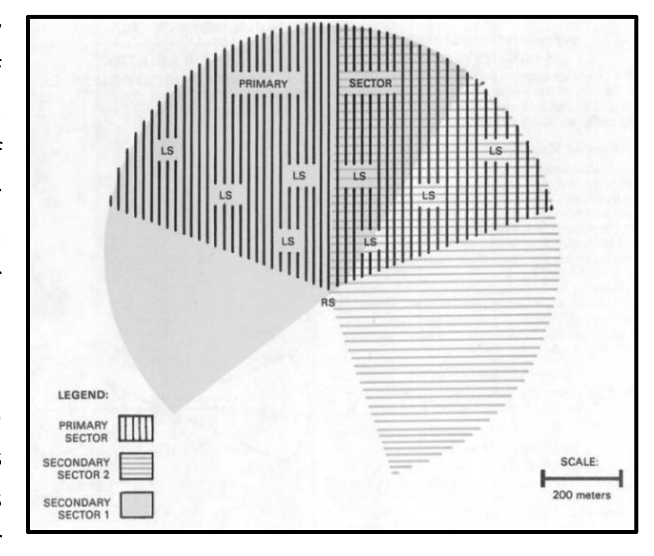
- Is not crew inside or even near to RS it is fully automatic and remotely operated.
- Because of the distance between ECS and RS the high frequency signal cannot be transferred to ECS therefore from RS only processed data, digital target coordinates are forwarded instead of raw data. (The RS processes the raw analog data and translates them to digital coordinates.) For Soviets SAM – such as Volhkov and Neva or the first S-300 variant the PT/PS – raw data could be displayed which made possible manual target tracking with handwheels. (See in more detailed about manual target tracking in the chapter about SA-75/S-75.)
- RS is placed ahead the ECS therefore a single FU (battery) can cover only 270 degree in azimuth 360 degree is impossible. All equipment of the FU is placed behind the RS.

  The RS has ± 45 degree azimuth limitation for target acquisition and ± 55 degree for target tracking. Of course the RS can be turned left of right but from the 270 degree zone only within 90 degree arc can be done target search and within 110 degree the target tracking.



Typical layout of a Patriot FU (battery)

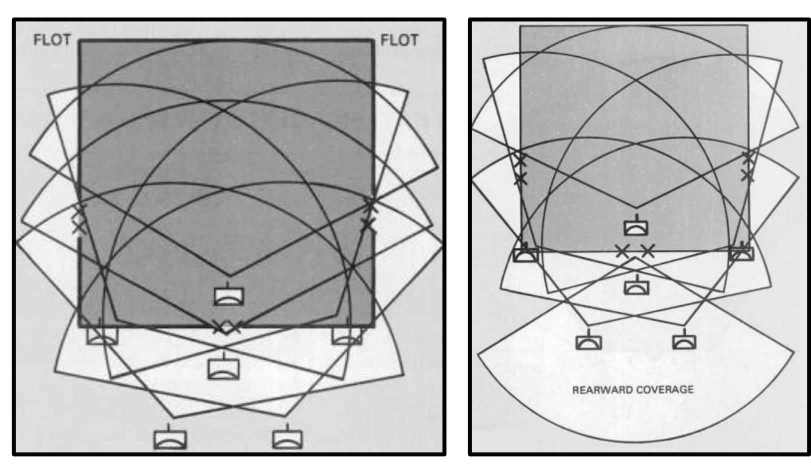
The 8 pcs of LS of an FU is divided to two sections. Half of them can launch missiles to left and main zone another half to right and main zone. This is consequence the slant angle and hot launch method; missile leaves the storage container using its rocket engine.



At first sight the listed restrictions and limitations may seem very serious but they are not because the FUs of a Patriot battalion do not fight alone. Considering the total firepower and capabilities of certain variant of Patriot battalion with 5-6 FU is similar or even higher than a certain variant of S-300 brigade with 5 batteries but a single FU alone has much stronger restrictions then any variant of a single S-300 battery.

The launch method of missile made possible the build a simpler missile because the missile does not have to be rotated to target direction rotating the LS provides this feature. The S-300 vertical launch with gas catapult resulted a more complex missile but for exchange the battery has 360 degree launch capability. Because the main direction of the treat was clearly defined between the NATO and WPACT the 270 degree limitation of the Patriot was not so hard.

The combat potential and firepower to certain direction are strongly based on the automatic operation modes and the layout if the FUs. In field manuals of the system the impact of different layouts are deeply explained on the images above only some options are illustrated. Some declassified field manuals about the Patriot are in the attachments. On the diagrams above are visible the engagement zones is some configurations with 110 degree tracking limitation.

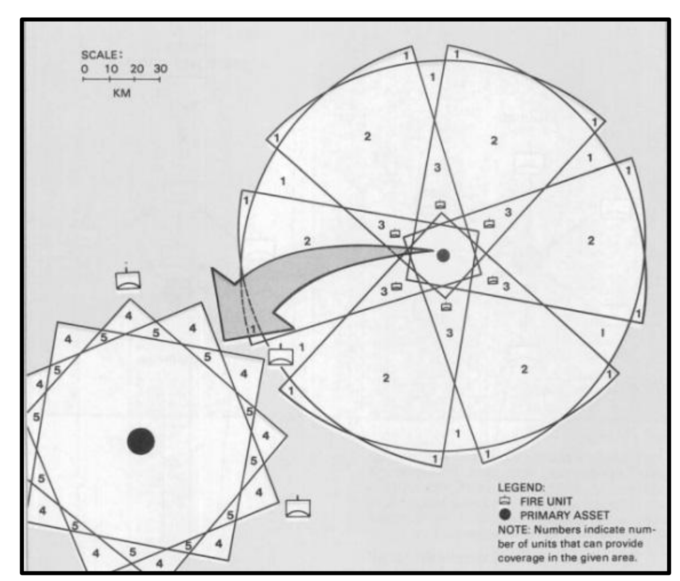


Some typical layouts of FUs

Because of the automatic operation of the FU are not available engagement zone diagrams unlike the Soviet SAM systems because the SAM operators are not in such decision making position as the crew of Soviet SAMs. The contemporary S-300 system were much more manual and directly human controlled than the Patriot.

The crew of the Patriot in the ECS operates very different way the FU; they just managing and supervises the activity rather than manually control the systems. The key for efficient operation is the preparation before the FU starts the operation. The crew designates zones which have to be defended around important objects, units or just airspace which should be denied from the enemy and also can be designed zones where system does not engage targets. Such zone can be for example and air corridor for friendly

units. After the zones have been created the software of the Patriot decides which target has to be engaged and the sequence either. As long as the system is active the crew only supervises the activity, can change priorities and zones if it is necessary but always the system decides about the launch the operators can deny or allow but there is not “missile launch” button on the control panel of the Patriot.



Some layouts of FUs; the values show the available FU quantity to certain directions considering the arc limitation of the RS.

The level of automatization was raised to a higher level the Patriot comparing to Improved HAWK Patriot does not have manual mode at all. The operators just supervise the system following the setup, they can adjust and create new zones, can change the to be engaged queue (TBEQ), can change the direction of launcher in case left of right launcher group runs out from missiles but always the system determines about missile launch considering the inputs the operator. The crew can delete targets of can prevent any missile launch in case of emergency. The Patriot launches as many missiles against as many targets as the internal logic and current setup determines as long as runs out of missiles of course considering limitations by the target and fire channels.



Patriot operator during work the dashed and other lines define the different kind of zones.

The operators of Patriot have much less option to intervene into the work of the battery. Operators of an S-300 anytime can designate and can launch missile on a single target while to achieve this with Patriot is only way to set such small zone where only a single target flies and only one target is on TBEQ list.[1] Even

[1] *This is totally theoretical scenario in reality setting such zone is not practical.*

with this restriction the system determine about the launch while the crew of S-300 anytime can launch a missile even the target is edge or out of the nominal engagement zone of the system. S-300 has “full manual” mode the Patriot does not have such operational mode.

After setup procedures – RS direction set, defended zones and safe corridors have been defined, etc. – in theory if operators did not want to change anything to adapt different tactical situations a Patriot battery (or battalion) can operate without any human operator intervention. Of course such action would be unwise because monitoring the system is necessary because of IFF and lots of other issues in a very dynamic environment for example the missile launchers sooner or later has to be reloaded.

The core control crew in only two men. Of course the technical, logistical and other crew assets are much larger than 3 men but they do not directly control the system they just ensures the technical reliability of the system and responsible for guarding and other tasks.[2] The operator crew is the following:

- **Tactical Control Assistant,** TCA is responsible for target designation for TBEQ.
- **Tactical Control Officer,** TCO is responsible for IFF and handling friendly forces as well as supervises the activity of the TCA and determines orientation of RS and fire doctrine.
- Radioman to keep the contact with other Patriot batteries and assets.

The working principle the (almost) fully automatic mode and IFF leaded to some friendly fire cases (which also happened many times with manually controlled older SAMs in Cold War on both sides) and some “almost” incidents. Because of uncertainty if IFF procedures and IFF beam width limitations is needed managing and supervising the work of the system and of course friendly air assets also have to be careful what they are doing and where because of airspace setup of Patriots.

In a misfortune case was downed an English Tornado strike fighter.[3] Following this incident an F-16 pilot destroyed the RS of a Patriot as self-defense because of fear of being downed[4] which was maybe overreaction the situation. These two cases are examples concerning automatic mode and IFF but the problem is automatic or at least semi-automatic mode cannot be discarded. In a frontline environment the (semi)-automatic operation is the only option where dozens of targets can handled especially considering the environment from low level airplanes up to tactical ballistic missiles. The simultaneous target engagement capability combining with ABM capability can be fully utilized only with (semi)-automatic. (This is also true for the Russian S-300 SAM family.)





Above left is the AN/MPQ-53 radar station (RS), right is the AN/MSQ-104 engagement control station (ECS)

[2] *In more detailed see in attachment in the FM 44-15 1986 (OBSOLETE) Patriot Battalion Operations.pdf document; page 188 (A-4). The used terms are not exact in the description it is the shortened and summarized form of the manual.*

[3] *https://www.theguardian.com/uk/2006/oct/31/military.iraq*

[4] *http://www.f-16.net/f-16-news-article787.html*

The Patriot has only one type of radar (AN/MPQ-53 or AN/MPQ-65 for later Patriot versions)[5] which used for both target acquisition and missile guidance. The engagement control station (AN/MSQ-104, ECS) handles the following tasks and operations: [6]

- Determines the ownership of the target (hostile, friendly, unknown, etc.)
- prioritize the targets
- prepares the launcher(s) and select the missile(s) according to launch mode and aspect of target(s)
- launch the missiles
- evaluate the success or fail and launch again if it is necessary

The Patriot meant a huge step forward comparing to HAWK not only because of the level of automatization but as well as considering target, missile channels and range which was increased from 35-40 km to 68 km. The Patriot had simultaneous engagement capability even it had only single fire control radar per battery which also served as target acquisition radar.

The Patriot uses TVM (Track via missile) guidance which is more or less is hybrid of the RCG and SARH guidance types. A single battery is capable to guide simultaneously missiles against 8 targets 2 missiles for on each targets (8 target and 16 missile channels) but only 3 missiles can be in terminal phase (the last 10 seconds) when missile demands very frequent target illumination from the RS. This means much more missile can be on route to many targets but the target illumination requires very precise timing this is why is essential the semi or fully automatic operation mode of the system. Is not such human on the Earth who could determine which target should get the highest priority, which missiles in what sequence will reach target and set target terminal phase illumination.

The rate of fire of the Patriot is superior comparing to S-300P family because of difference design approach. S-300P does not have terminal phase limitation it has 6 target and 12 missile channels. For the S-300 one target channel is “busy” for the duration of whole engagement from target tracking until end of evaluation of the hit while even Patriot has only 3 target channel limitation in terminal phase but it handles much more dynamic way the target illumination which eventually provides higher fire rate. The downside of the more dynamic method requires much more computing capacity and cannot be operated manually the system while the S-300P family has manual mode even manual target tracking which small handwheels similar to S-75/125 systems.

The targets have to be prioritized by the available time for interception which is derived from their velocity (speed and direction) and distance. Even just considering aircraft as targets is impossible for a human operator to do the process in case just a handful of target while in a real situation dozens of targets can be in range and one hundred can be displayed on the screen. Even the base Patriot had only very limited ABM capability TBMs also had to be handled. We can see why only semi-automatic and automatic operation modes are available for operators in full manual mode the capability never could be utilized.

Comparing to Patriot the old one target channel capable Soviet SAMs were used in very primitive way before the IADS support systems. Considering the gathered data of target acquisition radar of the battery the SAM battery selected a target and engaged it. The engagement lasted until the SAM battery had missiles or target was destroyed or cancelled the engagement by the commander. In worst case the SEAD suppression forced to turn off the fire control radar in case incoming ARM was detected or the battery was destroyed. Comparing to this method the Patriot with fast computer (considering early ‘80s level) and software using mathematical algorithms is able to engage targets according the configured priorities and

[5] *https://goo.gl/73QOqm*
[6] *https://goo.gl/wUmDih*

available time for interception up to 100 scale target where human operator is not even able to track every target. The Patriot can defend itself against anti-radiation missile (ARM) the maximal target speed is 1100 m/s.

Using the network (data link) between batteries the Patriot battalion is able to triangulate jamming targets using data of multiple ECS through the ICCs. The structure of the Patriot battalion makes possible to change the TBEQ or direction of RS or LS from ICC. The batteries literally can be remotely controlled from ICC the battalion commander can override the decisions of the TCO of the batteries. Using the data link and assets in the network (EW radars, AWACS, other Patriot batteries) the batteries can have much better tactical information than any other previous systems even SAMs in SAGE.

The ICC similar to ECS has three man crew which means in the most extreme case the total firepower of a Patriot battalion is under authority only two men (and of course the software of the equipment). For each batteries target prioritization is handled by the ICC similar to Volkhov/Neva SAMs with Vektor/Szenezh regiment level IADS systems or the PBU vehicle for S-300 SAM family in USSR.

The communication within the Patriot battery is different from S-300 because every ECS (battalion) is able to establish network and communicate directly with each other without the higher level ICC while within an S-300 regiment/brigade the communication and link is established one level higher. The batteries of and S-300 regiment/brigade can be linked via the PBU (for ex 5K56) of the command battery. Regardless each ECS can communicate with each other no one of them can override and take over control (RS, LS setting and modifying the TBEQ) other batteries this level of authority is given only to ICC and battalion commander.

The Patriot has only two operational modes the semi-automatic and automatic; they are very similar considering the work cycle of the system which is described below the only difference between them is marked green is part of the cycle of semi-automatic the cyan is part of the automatic mode. The cycle of the Patriot is the following:

- RS (Radar Station) scan and acquire targets and track them or can use the gathered data of other assets via data link.
- The system analyzing the track and locations of the tracked target to determine the flight path comparing to defended objectives, safe zones.
- IFF check what can give the following results:
  - *True friend (friendly aircraft with IFF mode 4 response)*
  - *Special Friend*
  - *Assumed friend*
  - *Unknown*
  - *Hostile*
- By analyzing the track and flight path of the target classify targets as:
  - *ABT, Air Breathing Target*
  - *SOJ, Stand Off Jammer*
  - *ARM, Anti-Radiation Missile*
  - *ARMC, Anti-Radiation Missile Carrier*
  - *TBM, Tactical Ballistic Missile*
- The system determines which targets mean immediate threat for the Patriot battery itself. (Self Defense Threat)
- The system determines which TBM mean threat for defended objects or zones itself.
- Targets are displayed on screens of TCO/TCA.
- TCA designates target(s) with using mouse and press the ENG button. (S/I)

- Target(s) is automatically designated by the software.
- Target(s) are put on the TBEQ list.
- The system determines which LS are used, the moment of launch, type of salvos and the type of used missile(s) operators do not have any authority about these factors.
- The system launch missile(s) then following the predicted hit analyze the result of engagement and make decision about additional launches or removes target from TBEQ.

<u>The missiles can be launched with different salvo settings depending on target types and priority by the followings:</u>

- ***Shoot look shoot***

  This mode is used typically against airplanes (air breathing targets), one missile is launched against a single target. Following the terminal phase and evaluation of the forecasted hit can be launched another missile against the same target if it is necessary because of the miss. In automatic mode this salvo mode is used.

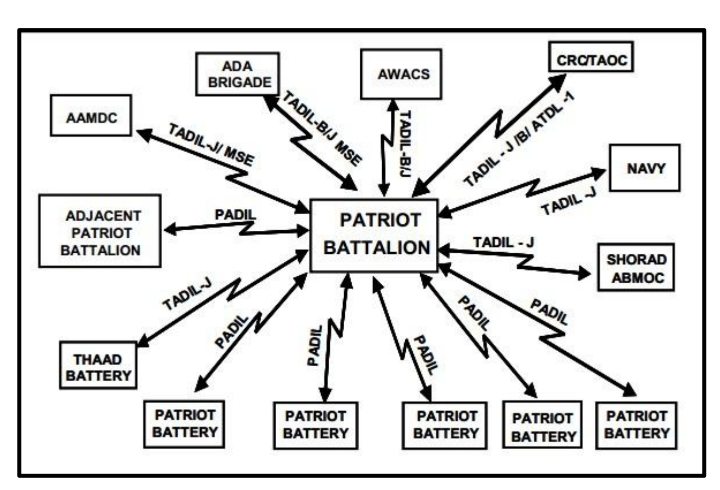
- ***Ripple***

  Two missiles are launched with 4.2 second interval. Missile can be launched from the same or even two different launcher (LS) the launch sequence is repeated with 4.2 second interval. Against large and multiple flights is used this salvo where targets are relatively close to each other. Following a hit the following missiles can change their direction to the next target thanks to the TVM guidance method.

- ***Salvo***

  Two missiles are launched with 1.2 second interval. This method is used typically against ballistic missiles or ARMs where the desired probability of kill is much higher and is a very short time to engage and destroy the targets. This is a less desirable mode in case lots of airplanes (air breathing targets) are the targets because the battery very quickly can run out from missiles.

It is remarkable all computing power demands at late served such computer which today's standard had laughably small memory and CPU speed. The first Patriot had a dual core redundant CPU with 6 MHz clock frequency also with 2x256 Kbyte redundant memory. For comparison the C64 in 1982 had 1 MHz CPU, 64 Kbyte RAM and 20 Kbyte ROM.



On left are the different types of data link which are used by the Patriot. (About data links you can find more information in manuals in the attachments.)

The Patriot has a special feature comparing to non-digital SAMs for better low level target tracking and target discrimination. Following the deployment the battery the RS can scan the terrain around the RS and creating the digital map of the surrounding area which is stored in the memory of the system.

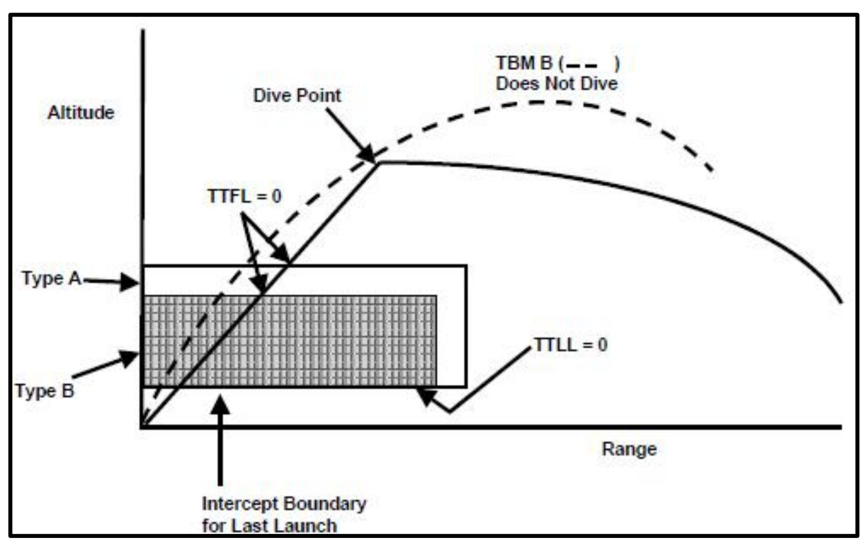
Thank to this digital map the low level targets in ground clutter can be separated from the background noise because the distance of the terrain is stored in the memory and anytime can be

compared to the parameters of the target. The disadvantage of this mode the time requirement because creating the map requires about 1 hour when the radar emits and can be targeted by ARMs while the battery itself is not combat ready. If anybody which to use Patriot as a mobile army air defense SAM has to consider the advantage and disadvantage of terrain mapping. Is not a coincidence that Patriot batteries have assigned short range air defense units (FIM-92 Stinger MANPAD)

(In Cold War Patriots were deployed into fix sites therefore as long as Patriots did not leave the SAM site this would not be an issue much before any engagement had the terrain map.)

The Patriot had anti-ballistic missile (ABM) capability from the beginning but this feature was badly interpreted by the media and most of the people during and following the Operation Desert Storm. The maximal target speed of MIM-104A missile was 1100 m/s which made possible engage 150 km range TBMs but mostly only for self-defense purpose. The battery could defend itself against a TBM attack but covering larger area and friendly troops was not possible. Of course the launch can be authorized at bigger distances by overriding the logic of the system but not surprisingly the probability of the kill in this case is much smaller as we could see during the Desert Storm where many of the missiles missed BMs which were beyond the parameters of the Patriot. The experiences of Desert Storm had strong impact of the further development of the Patriot family.

(As we can see later the range of S-300 family against airplanes can be 150-200 or even 250 km but against fast and long range BMs only 30-40 km.)



Flight path of a BM with aero braking capability.
(TTFL = time to first launch, TTLL = time to last launch)

At end of '80s a new type of TBM the OTR-23 Oka appeared in the inventory of USSR which meant a new kind of threat for the Patriot. Not only the maximal speed of the BM was problematic but the BM had different trajectory from pure ballistic it was able to create a "break" with aerodynamic braking.

The "break" maneuver could distract the logic of the Patriot because the calculated impact point can be changed close to the battery which changes the TBEQ and collapse the scheduled missile launches. In case the system is not enough fast to adapt to the new targets launching missile in time could be impossible. If already has been launched missile likely will miss and more missile launch is necessary because of the very different new calculated intercept point. To adapt the system for new kind of threat both software and

hardware changes were necessary. The later Patriot variants had different ABM capabilities as the base variant especially after it has got dedicated ABM missiles.[7]

Similarly to Soviet S-300 the missile of the Patriot is technically a terminal and mid-course guided ballistic missile. The missile flies to the calculated intercept point according the target parameters at the moment of the launch using ballistic trajectory. Of course in mid-course adjustments can be done in trajectory to minimize the harder correction in terminal phase. Against non-maneuvering targets only terminal correction is necessary.

1984, Patriot	MIM-104 Standard missile 68,5km range analog proximity fuse (150 km ballistic missile range with 1100 m/s burnout speed but the RS limited the effective range of the system)[8]
1986, Patriot	MIM-104A missile 68,5km range digital proximity fuse
1986, Patriot PAC-1	MIM-104B SOJC missile 160*km range *(*only in Home On Jam mode)*
1990, Patriot PAC-2	MIM-104C ATM missile 160km range, burnout speed is increased to 1700 m/ New warhead with dual role proximity fuse
1995, Patriot GEM	MIM-104D GEM missile 220km range MIM-104E GEM+ missile 220**km range ***C missile [ATM] upgrade to D [GEM] capability got GEM+ designation*
2001, Patriot PAC-3	MIM-104F PAC-3 missile 30 km range *ATBM missile*

The MIM-104 and MIM-104A variants were adequate against airplanes (air breathing targets) but against TBMs generally were not because of the distribution of shrapnel cloud of the missiles and because of missile kinematics. The MIM-104B had the same range against non-jamming targets as 'A' variant but against stand-off jammer (SOJ) airplanes had larger. The length of gliding phase was increased and in terminal phase without the data link between the RS and missile could manage the terminal guidance against jamming targets.

Of course the SOJ airplane can jam as many radar stations as can but it does not know the position of the missiles incoming towards to itself therefore it cannot their receivers while the missiles can detect the direction of the jamming source and intercept with weaker leading guidance without knowing the distance of the target. This makes very powerful the network based SAMs and specially the SAGG guidance of S-300 family with over the bit more simple TVM.

All of missile up to early '90s is common Patriot could defend only itself with adequate efficiency but was not able to defend other troops nearby to the battery only against air strikes by airplanes could provide cover. The chance to hit against BMs was possible only with minimal offset distance. (See in another chapter the meaning of offset distance.)

The new MIM-104C ATM missile provided the strongly upgraded ABM capability of the PAC-2 variant of the Patriot. The missile got new warhead with dual mode proximity fuse. The weight of the warhead increased the size and weight of individual shrapnel was also changed from 2 gram to 45 gram to have enough destruction power against conventional BMs which are more damage resistant than nuclear warhead equipped BMs. The dual mode fuse made possible to create different shrapnel distribution against very

[7] http://www.scribd.com/doc/12772502/fm3-01

[8] *It is similar case to S-300PT where the RCG guidance restricted the range comparing to huge kinematic range of the missile.*

high speed BMs and airplanes because the relative velocities are totally different against a BM than a much slower airplane.

The MIM-104D/E GEM missile variant got further capability upgrades in ABM area and lower RCS targets and the TVM guidance data link also was enhanced. Thanks to the upgrades the maximal target speed was increased to 3000 m/s which made possible intercept BMs with about 1000 km range.

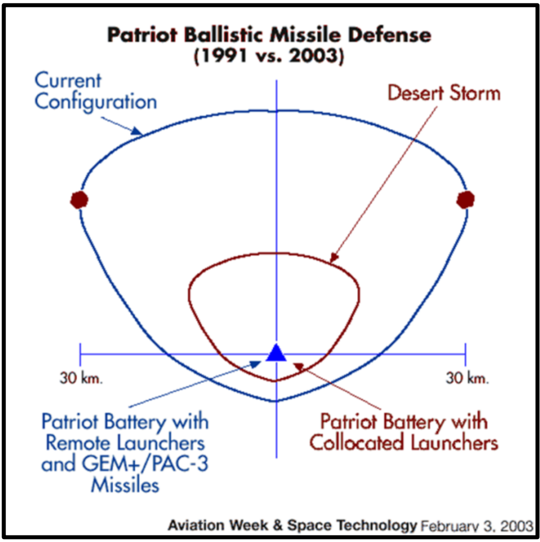
The firepower and ABM capability of PAC-3[9] variant strongly increased the PAC-3 variant reached the specified final capabilities in three steps; below the capability of "Configuration 3" PAC-3 are described. The main point of PAC-3 was make possible the area defense and be able to engage targets with large offset distance comparing to ECA and RS with a new smaller dedicated ABM capable missile. The main difference between the previous variant are the followings:

- The AN/MPQ-53 radar is replaced with AN/MPQ-65.
- The new MIM-104F missile is much smaller (diameter) which make possible to load 4 pcs MIM-104F in the volume of 1 pc MIM-104A/B/C/D/E missile.

  Mixed load is possible when only 1 larger missile is replaced with 4 pcs MIG-104F but is also possible to load 16 pcs of MIM-104F into a single launcher (LS). This loadout is very rare because it has only very little sense concerning firepower distribution. In some cases only two cell launchers are used see the images at the end of the chapter.
- The MIM-104F missile is smaller but its range is only 30 km but against BMs.
- The MIM-104F is fundamentally different from larger missile of the Patriot because it has active radar homing guidance and destroys the target with direct impact it does not have warhead. Because of the very small missile diameter the radar operational frequency is 20 GHz.
- The MIM-104F because of lack of warhead needs a very precise control and maneuvering capability. The missile besides the traditional missile fins and stabilizers also equipped with 180 pcs small pulse solid propellant rocket motors which are mounted in the fore body of the missile (they are called Attitude Control Motors, or ACMs). [10]

The PAC-3 following the 3rd stage of development became capable to perform distributed deployment of launchers. Using the VHF data link only with a single ECS the launchers can be deployable in 10 km range scale to any direction from



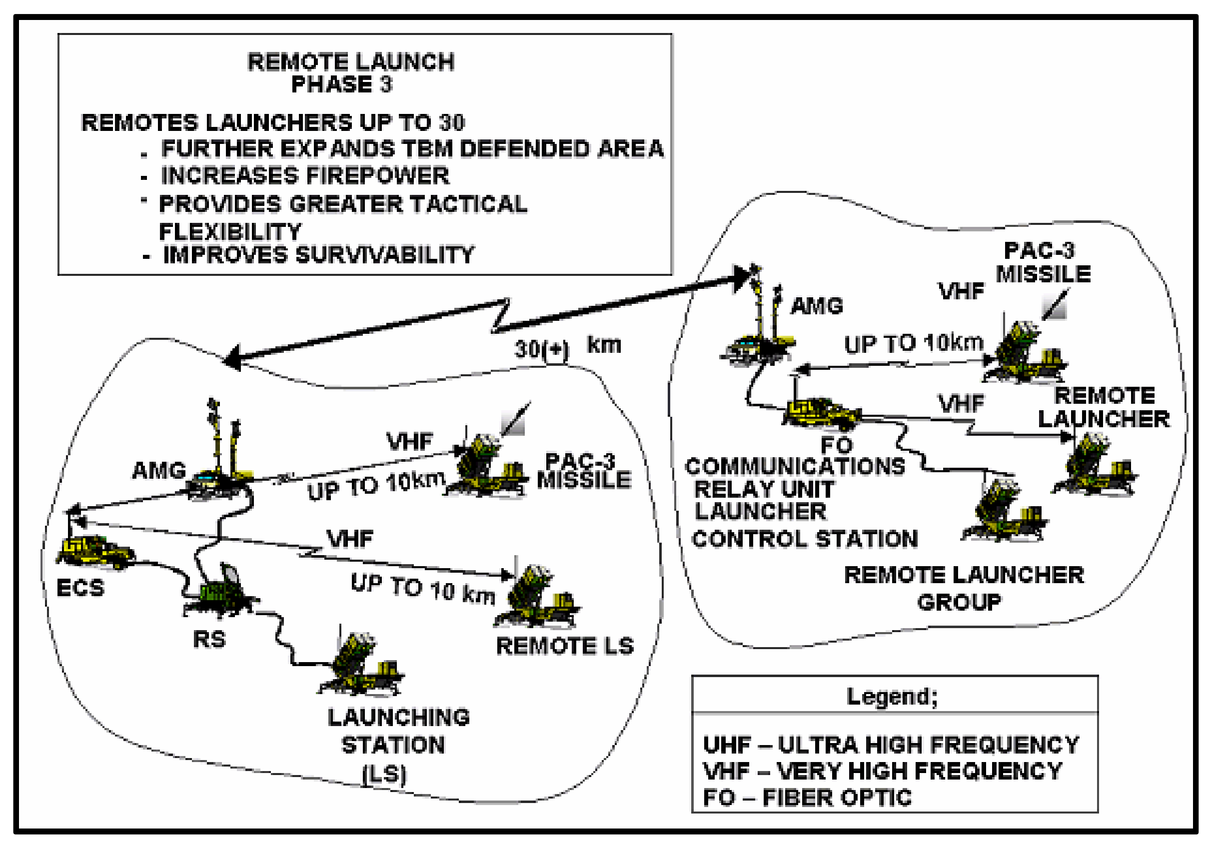


The difference between area defense capability in 1991 and PAC-3 variant .On the image above the impact area of the BMs are shown. On the diagram above we can see in 1991 during Operation Desert Storms such ABM capability was demanded by politicians which was not available deployment of Patriot in Israel had a political message than real tactical impact.

[9] https://www.youtube.com/watch?v=xU9C2iLm764

[10] *The ASM-135 ASAT missile used similar rocket motors because lack of other control methods which can be used in space.*

ECS which makes possible to cover much larger area than a single Patriot battery could do before PAC-3 variant. This capability was enhanced so strongly nowadays is possible to detach LS from ECS and it can have its own AMG and using the VHF data link the relay station can be 30 km away from the single RS and ECS of the battery. Using only a single radar and ECS is possible to cover 4000-8000 km^2 size area with a single battery. The distributed deployment very likely is possible only with full PAC-3 configuration because of the limitation of RS in case of launchers are father away it means much larger search and tracking range is needed for ABM role.



PAC-3 deployment structure and deployment distances.

In Soviet/Russian terminology PAC-3 can be placed somewhere between division and army level ABM system it can defend one or some division size units on the field or can defend a larger city and its urban area. The one level higher ABM system is the THAAD (Theatre High Altitude Area Defense System).

As its name suggest it is a theater level ABM system with about 200 km range which using Russian terminology it makes front level SAM system. (In fact none of the Soviet or Russian army air defense SAM system achieved so far such large range in ABM role, see later the S-300V/VM variant.

The field operation of Patriot was designed basically with Patriot battalions with many Patriot batteries but also was considered not only in pure Patriot units mixing HAWK + Patriot also was possible. Because the Patriot was designed as a long range SAM and later ABM system against low and slow flying targets it is not so effective. In the Patriot battery can be integrated the MIM-72 Chaparral and around the battery (~ 2km distance) FIM-92 Stinger units also can be deployed. The protection of single Patriot battery against SF and commando operations was secured by a platoon sized unit. (In WPACT SAM batteries got the same level of protection.)

The origin of the Patriot family is dated to ‘70s the upgraded variants of the system will remain is service in the following decades (similar to S-300/400 family in Russia).



On the left and red are the TCO and TCA between them is the radio(wo)man. The displays are still CRT based with green monochrome color. On the picture above it the "classical" Patriot but the later variant are only marginally different from this set-up. On the control interface some new buttons are available they are basically the same with different screens regardless the strongly upgraded missile and other electronic equipment.



Above is the control interface of the most advance Patriot system with color LCS screens the virtual control board got only some new buttons comparing the "classical" Patriot.



Above is the missile launch with the "classical big" missile. Comparing to the S-300 is not used a gas catapult system (cold launch) rather the missile engine push from the missile container the missile (hot launch).



Above is a two cell launcher only 2x4 missiles can be loaded (practice variant.)

Finally as usual some video about the system from the '80s.

https://www.youtube.com/watch?v=g3cuf14TSq8
https://www.youtube.com/watch?v=HfLxOvaLZho
https://www.youtube.com/watch?v=yynlGg38Dzg
(From 8:10 is explained the basis and the point of phased array radar)